International Journal of Electronics, Communication & Instrumentation Engineering Research and Development (IJECIERD)
ISSN(P): 2249-684X; ISSN(E): 2249-7951
Vol. 4, Issue 1, Feb-2014, 1-8

REVIEW OF MULTIMODE TECHNIQUES FOR SOFTWARE DEFINED RADIO

PATIL A.T.[1] & WADHWA L.K.[2]

[1]Department of E & TC, MBT Campus, Islampur, Maharashtra, India

[2]Department of E & TC, DYPIET, Pimpri, Maharashtra, India

ABSTRACT

Nowadays, the behavior of a communication system can be modified by simply changing its software and resulting new radio model is called Software Defined Radio. SDR is the popular research direction of the 3G and 4G mobile communication. This model uses both analog and digital modulation and demodulation methods which are discussed in this paper. The aim is to study and understand multimode techniques (i.e. amplitude modulation, Frequency modulation and binary Phase shift keying ,binary Frequency shift keying, quadrature phase shift keying) of SDR in audio frequency band.

KEYWORDS: SDR, Modulation techniques, Modulator, Demodulator

INTRODUCTION

The traditional radio communication systems required a lot of hardware components such as demodulator, detector, filter, etc. which makes the platform cost very high for study and research.

SDR makes it possible to implement the radio communication process only with software. Comparing to the traditional radio communication systems, SDR leaves all the hardware and replaces them by pure and compatible software. This solution also gives a great benefit in flexibility because a SDR receiver is able to decode all the signals.

There are five modulation methods studied in this project. The modulation and demodulation processes are designed according to the related theory [2] [3] [4].

MULTIMODE TECHNIQUES

Modulation and Demodulation

The signal with high frequency has been transmitted in all radio communication system. For a long distance transmission, the signal must have high frequency on the other hand; the height of antenna has a strong relationship with the signal frequency. If the signal frequency reduces, the height of antenna increases. For transmitting low frequency signal may require a very high antenna which is impossible. Whenever the signal with low frequency needs to be transmitted it is necessary and important to modulate it to a high frequency signal. Only in this way can the signal be transmitted in the radio communication system [4].

The original source signal is called modulating signal. The signal used to carry the modulating message is called carrier signal; typically it is a high-frequency sinusoid or cosine waveform. The carrier signal can be transmitted over a long distance [5]. The process of making the RF carrier signal carry the original source signal with low frequency is modulation. Modulation can be done by varying one or more features like Amplitude, Frequency and Phase of a carrier signal. Receiver has to process the modulated carrier signal and get the original source signal; this process is demodulation. Its function is opposite to that of modulation.

The various techniques of modulation and demodulation used in SDR are discussed below.

Analog Modulation and Demodulation

In the analog modulation, parameters can be changed in carrier signal are amplitude and angle, while the angle contains frequency ω and phase θ. When the amplitude of carrier signal varies as the modulating signal, it is amplitude modulation (AM); if the other two parameters are changed, it is called frequency modulation (FM) and phase modulation (PM) respectively.

Amplitude Modulation and Demodulation

Amplitude Modulation

Amplitude modulation is a linear modulation process. AM is defined as a system of modulation in which the amplitude of the carrier is made proportional to instantaneous amplitude of modulating voltage. In other words, in amplitude modulation, the carrier signal's amplitude Vc varies according to the instantaneous amplitude of the modulating signal voltage em. Figure 1 shows the defined voltage in amplitude modulation.

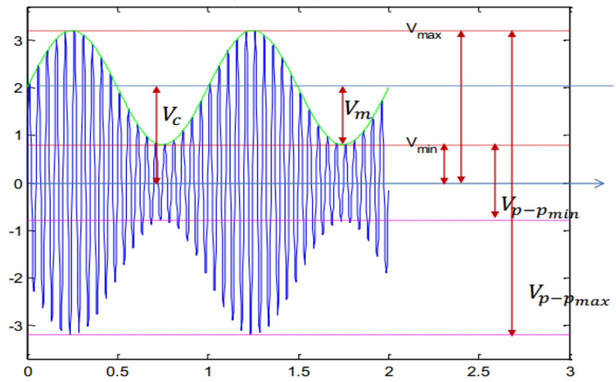

Figure 1: Voltage Define in AM

The degree of modulation is described by an important parameter called modulation index. It affects the shape of the AM signal and expressed as ***m*= *Vm*/*Vc***. If the modulation index is more than 1, the carrier signal will turn off when **Vm** equals the lowest amplitude. Thus **m** should not be more than **1**, namely ***m<=1.***

An imaginary line drawn along the peak value of each wave cycle is called envelop of AM signal. It can be expressed as

$$e_{ENV}=V_M+Vm*sin\omega_m t \tag{1}$$

The instantaneous voltage of AM signal e_{AM} should be the multiplication of the envelop and the carrier signal, thus it can be expressed as

$$e_{AM}=e_{ENV}*sin\omega_c t \tag{2}$$

Namely,

$$e_{AM}=V_c(1+m*sin\omega_m t)*sin\omega_c t \tag{3}$$

e_{AM} is the AM signal which has already got the information to be transmitted to the receiver [6].

Amplitude Demodulation

Demodulation is an opposite process of modulation. Coherent and non-coherent are two different methods used to carry out the demodulation [7]. When the phase of the received signal is knows to receiver, in that case coherent demodulation can be used. The general coherent demodulation process is shown in Figure 2.

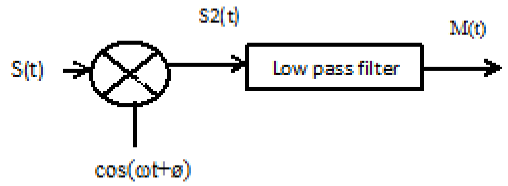

Figure 2: Block Diagram of Coherent AM Receiver

The key procedure is that the receiver must produce a carrier signal which has same phase and frequency with the received signal's carrier signal.

The other method is non-coherent demodulation, in which the carrier signal is not necessary but the envelop line is used. The demodulation process is shown in Figure 3.

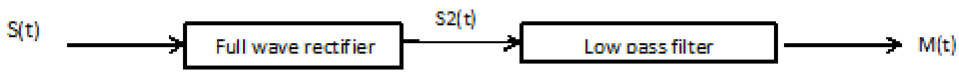

Figure 3: Block Diagram of Non-Coherent AM Receiver

Full wave rectifier makes all the inputs to be positive or negative i.e. it converts the whole signal to DC. The low pass filter is designed pass the signals with expected frequencies.

Frequency Modulation and Demodulation

Frequency Modulation

In FM, frequency of carrier signal varies according to modulating signal keeping amplitude of carrier constant [4].

In FM, the modulation index is defined as the ratio of maximum frequency deviation and the modulating signal's frequency. The formula

$$m = \Delta f / fm \tag{4}$$

Suppose a cosine wave fm (t) is the modulating signal and a sine wave fc (t)=Ac sin(2πfct) is the carrier signal, then the modulated signal should be

$$x(t)=Ac\ \sin(2\pi \int_0^t f(\tau)d\tau) \tag{5}$$

f(τ) is instantaneous frequency which should be (fc+$\frac{\Delta f}{Am}$*fm(t)), then we can transfer the Equation (5) to be

$$x(t)=Ac\ \sin(2\pi \int_0^t f\ (fc+\frac{\Delta f}{Am}*fm\tau\ )d\tau)\ (6) \quad =Ac\ \sin\ (2\pi fct+2\frac{\Delta f}{Am}\int_0^t f(\tau))$$

For

fm(τ)=Am cos(2πfmτ),

$\int_0^t f(\tau)d\tau$= Am*[(2πfmt)/2πfm],

Then we can obtain

x(t)= Acsin(2πfct+2$\pi\frac{\Delta f}{Am}*Am$*[$sin$(2$\pi fmt$)/2$\pi fm$]

$$= Ac\sin(2\pi\ fct+\frac{\Delta f}{fm}*sin(2\pi fmt)) \tag{7}$$

In which $\frac{\Delta f}{fm}$= m and x(t) is the modulated signal.

Frequency Demodulation

Similar with AM, FM also uses coherent and non-coherent methods of demodulation. Narrow band FM signal are demodulated by the coherent method and the receiver knows the phase shift of the received signal. So that the coherent method is only applied in a limited area. Narrow band FM and wide band FM comes under the non-coherent method which are applied in unlimited area [6].

Digital Modulation and Demodulation

The requirement in digital communication is to transfer the digital message from one place to another. There are two types of transmission first is baseband transmission and second is pass band transmission. Baseband transmission have low frequency range and passband transmission has high frequency range. The set of modulation techniques for shifting the digital message from baseband to pass band are termed as digital modulation techniques.

Digital message will have only two levels 0 & 1.It has amplitude shift keying(ASK),frequency shift keying(FSK) and phase shift keying(PSK) are basic digital modulation techniques. The BPSK, QPSK and BFSK these modulation techniques are discussed in next section [5].

BPSK Modulation and Demodulation

BPSK Modulation

BPSK (Binary Phase-Shift Keying) is the simplest PSK. In BPSK the carrier signal's phase varies between two values according to the modulating signal. BPSK is also called 2-PSK for the two values has 180°difference[7].The PSK is defined as the process of shifting the phase of the carrier signal between two levels, depending on whether 1 or 0 is to be transmitted. When binary symbol is one the PSK signal will have the original carrier signal. Alternatively, the PSK signal will have the 180º (Π) phase shifted carrier signal when the binary symbol is 0.

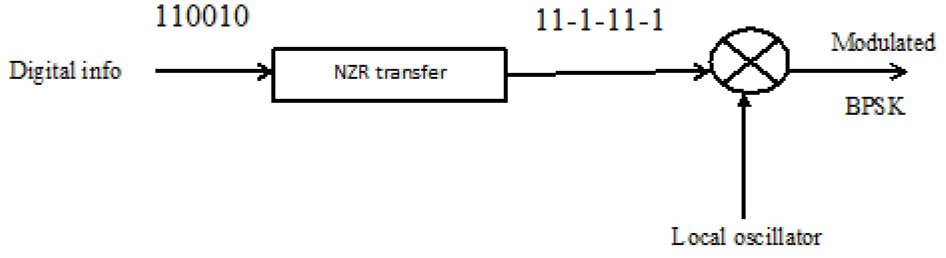

Figure 4: BPSK Modulator

Suppose, carrier signal is x1=cos(2*Π*fc*t), phase of this carrier is 0,from mathematic knowledge, it can be known that

$$x2= cos(2*\Pi*fc*t+ \Pi)$$

$$=-cos(2*\Pi*fc*t)= -x1 \quad (8)$$

Equation (8) offers the method to modulate the signal. When signal is bit 1, BPSK signal is x1, otherwise it is –x1.

BPSK demodulation

The message can only be demodulated by coherent detection. The incoming BPSK signal is multiplied with the carrier signal with phase shifted zero degree and phase shift 180º. Thearrived BPSK signal is

$$a(t)=A\cos(2\pi fct+k\pi+\varphi)\ (k=0,1) \quad (9)$$

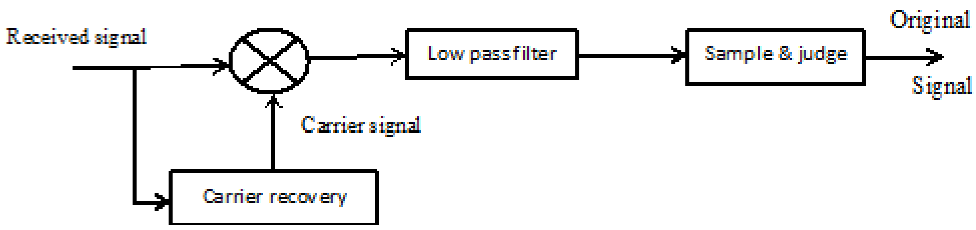

Figure 5: BPSK Demodulator

Carrier can be recovered from *a(t)* divide this signal's frequency to be half through a low pass filter, the carrier signal can be recovered to

$$x' = \frac{1}{2}A^2\cos(2\pi*fc*t+\varphi) \quad (10)$$

Now Comparing Equation (10) with Equation (9), there is a phase difference, which gives bad demodulation result. To get the right carrier signal x' has to be shift a phase of φ. Finally the correct carrier is obtained

$$Carrier=\frac{1}{2}A^2\cos(2\pi*fc*t+\varphi) \quad (11)$$

QPSK Modulation and Demodulation

In quadrature PSK system, the phase of the system is allowed to vary by 90º,thus giving rise to four signals with phase angles of 0º,90º,180º and 270º.It is known as 4- PSK. It required half bandwidth of the BPSK bandwidth requirement [6].

QPSK modulation

QPSK is complex than BPSK. There are four different patterns 00,01,10 and 11. So the carrier signal's phase varies among four values for each pattern.

Table 1: Phasor Originating from Combination

x(t)	x'(t)	s(t)	s'(t)	y(t)	Phasor
0	0	$\cos\omega_c t$	$\sin \omega_c t$	$\cos\omega_c t + \sin \omega_c t$	1
0	1	$\cos\omega_c t$	$-\sin \omega_c t$	$\cos\omega_c t - \sin\omega_c t$	4
1	0	$-\cos\omega_c t$	$\sin \omega_c t$	$-\cos\omega_c t + \sin \omega_c t$	2
1	1	$-\cos\omega_c t$	$-\sin \omega_c t$	$-\cos\omega_c t - \sin\omega_c t$	3

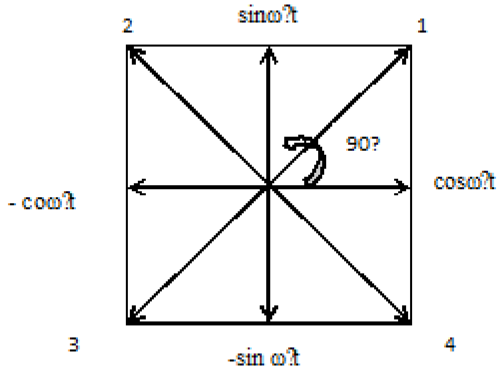

Figure 6: Vector Diagram of Phasor

QPSK Demodulation

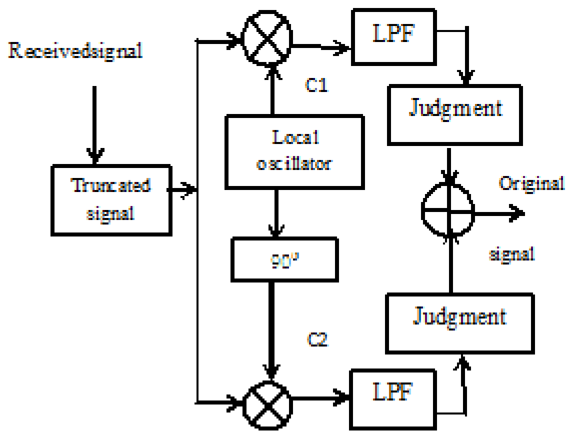

Figure 7: QPSK Demodulator

There are two different carrier signals C1 and C2 same with the carrier signals used in the corresponding transmitter. In QPSK demodulation, both carrier recovery and preamble controls the problem of phase shift. The truncated signal can be demodulated with the carrier signals generated by local oscillator.

BFSK Modulation and Demodulation

FSK is a digital modulation technique defined as the process of shifting the frequency of the carrier signal between two levels, depending on whether 1 or 0 is to be transmitted. Thus, the frequency of the transmitted signal is high for 1 and low for 0.

BFSK Modulation

The binary signal x(t) is used to generate waveform

$$x_{BFSK}(t) = A\cos(\omega_0 \pm \Omega)t \tag{12}$$

The + sign is applied when x_t= +X, and the minus sign is applied when x_t= -X. It may be noted that since, ω_0 >> Ω, the lower of two frequencies , ω_0 - Ω, also falls in RF range and hence it is transmission through the space using antenna is convenient.

BPSK Demodulation

BFSK signal can be demodulated easily with a non-coherent method. Received signal pass two different band pass filters to get the corresponding signal. And then through the envelop detector the two branch's information has been obtained. Lastly after making judgment and comparing two branches outputs the information is demodulated out.

FUTURE SCOPE

The above mentioned modulation techniques will be used for new generation communication technology. The SDR mostly used in portable devices such as PDAs, smart phones, laptops and so on. The cellular technologies like GSM, WCDMA, and LTE etc. are more supportable with SDR. It can support the different services like location based service (GPS), World Wide Web (www), video calling, video broadcasting, e-commerce [8].

CONCLUSIONS

In this paper five modulation methods have been studied, two analog modulation methods and three digital methods. From this discussion it can be known that phase modulation method is more difficult than frequency modulation method for the receiver has to know the phase it should receive. The non-coherent demodulation is simplest to implement. To do this practice only one laptop installed with MATLAB is enough. It is also can be a lab for students to enhance the understanding of concept of modulation and demodulation.

Along with the modulation methods many other aspects can be improved. Such as to add preamble in transmitter signal and then the receiver can be modified to check the preamble first. If the preamble is right it keeps on receiving the signal or it can reject the transmitting. A checksum also can be added in receiver to check if the signal is right.

REFERENCES

1. "Software defined radio" by Yang & Hanzo, IEEE Communication Magazine (pg.174-183), March 2002.
2. Theodore S. Rappaport, Theodore Rappaport, 2002 Wireless Communications: Principles and Practice (2nd Edition). Prentice Hall PTR, ISBN: 0130422320.
3. A. Dutta, D. Saha, D. Grunwald, and D. Sicker. Smack: a smart acknowledgment scheme for broadcast messages in wireless networks. SIGCOMM Comput. Commun. Rev. 39(4): 1 5-26, 2009.
4. U.A. Bakshi, A.P. Godse 2009. Basic Electronics Engineering. Technical Publications. Chapter 8.5.
5. KunduSudakshina 2010. Analog and Digital Communications. Pearson Education India. pp. 163–184. ISBN 978-81-317-3187-1.
6. George Kennedy's 2011."Electronics Communication Systems", Tata McGraw Hill Publications.
7. R.P. Singh, S.D. Sapre 2013. "Communication Systems: Analog and Digital Signal", Tata McGraw Hill Publications.

8. Ziyi Feng“. A Software Defined Radio Implementation Using MATLAB” Information Technology 2013